Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

SHOUT
SHARE
IT

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1072

Washington, D. C. June 17, 1922

THE HANDLING, SHIPPING, AND COLD STORAGE OF BARTLETT PEARS IN THE PACIFIC COAST STATES.[1]

By J. R. MAGNESS, *Plant Physiologist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

CONTENTS.

	Page.		Page.
Introduction	1	Handling fruit for the canneries	12
Distribution of Bartlett pear growing in the Pacific Coast States	3	The cold storage of Bartlett pears	13
Handling fruit for shipment in a fresh state	3	Storage temperature	13
		Pear scald	15
		Summary	16

INTRODUCTION.

During recent years there has been a very considerable increase in the acreage devoted to the growing of pears on the Pacific coast. These plantings have been distributed in various parts of California, Oregon, and Washington. Careful estimates indicate that the production of pears will increase fully 50 per cent within the next five or six years.

Of the varieties of pears grown on the Pacific coast the Bartlett far outranks all others combined. It is a safe estimate that more than 50 per cent of all pears grown in Washington and Oregon are of this variety, while in California, the heaviest pear-producing State in the Union, probably 75 per cent of all pears grown are Bartletts. Furthermore, although the so-called winter varieties, coming into market following the Bartlett season, are increasing in popularity in some of the cooler growing sections, the Bartlett is practically the only variety being planted in large quantities in those districts in which it reaches its highest quality.

[1] This bulletin gives the result of a portion of the work carried on under the project "Factors Affecting the Storage Life of Fruit."

94444—22

The reason for the popularity of the Bartlett variety is readily understood. A very heavy bearer of fruits of large size and of very high dessert quality, it is the ruler of the fresh-pear markets during the weeks in which it is in season. Where canned it has a higher quality than any other pear and in regions where it can be produced successfully is practically the only variety that goes into the commercial canned-fruit trade. In some districts it is also dried very successfully, and a large demand has been created for the dried product.

With the constantly increasing production of Bartletts, however, it has become apparent that some means of holding the fruit in cold storage is vital to the industry in many producing sections. If the total season for fresh consumption can be lengthened by several weeks, a much larger quantity of fruit can be disposed of on the fresh-fruit market.

It is even more important that canners in certain sections be able to hold the fruit in storage. In some sections Bartlett pears and certain varieties of peaches reach canning condition at practically the same time. Since pears can be held more successfully than peaches, it is of great advantage to put a portion of the pears in cold storage and hold them until the peach-canning season is over. It also reduces the overhead expense of the cannery to prolong the canning season as much as possible. In former years heavy losses have been suffered by some pear canners, owing to fruit becoming overripe during the rush season. Much loss has also occurred in fruit that has been in cold storage, due to improper methods of handling.

During the past two seasons investigations have been carried on by the Bureau of Plant Industry to determine (1) the effect of the time of picking on the keeping, eating, and canning quality of Bartlett pears, (2) the comparative keeping and carrying capacity of fruit from different sections of the Pacific coast grown under widely varying climatic conditions, and (3) the method of handling fruit in cold storage which will give the longest keeping period and the highest dessert quality in the fruit upon removal from cold storage. Chemical and physiological studies have been made of fruit from different sections gathered at different stages of maturity and held under different conditions following picking. The results of some of these studies have been presented in detail in an earlier publication.[2] It is the primary purpose of this bulletin to discuss the results presented in that report, as they concern the practical grower and handler of Bartlett pears, and also to include the results of some additional investigations.

[2] Magness, J. R. Investigations in the ripening and storage of Bartlett pears. *In* Jour. Agr. Research, v. 19, no. 10, p. 473–500, 8 fig. 1920. Literature cited, p. 499–500.

DISTRIBUTION OF BARTLETT PEAR GROWING IN THE PACIFIC COAST STATES.

In California Bartlett pears are grown under a very wide range of climatic conditions. By far the heaviest producing area lies along the Sacramento River on reclaimed land below the city of Sacramento. This region produces about one-third of all the pears grown in the State. Another heavy-producing section lies in the foothills of the Sierra Nevada Mountains north and east from Sacramento and centering about the towns of Newcastle, Auburn, Colfax, and some others. This area lies in Eldorado, Nevada, and Placer Counties, mainly in the last. A third important region is the Santa Clara Valley, centering about San Jose. There are, however, large plantings of pears in all the region centering about San Francisco Bay, from 150 miles north of San Francisco to 100 miles south and east to the Sierra Nevada Mountains. Some sections of southern California are also beginning to produce pears extensively. Los Angeles County has a large acreage soon to come into bearing and is already a factor in the tonnage produced. The Antelope Valley, at the edge of the Mojave Desert, has a considerable acreage of pears, while at Tehachapi, at the summit of the range of mountains of that name, is another fairly large area. These regions in southern California are not yet in full bearing.

In Oregon the principal pear-producing section is in the Rogue River Valley, in the southwestern part of the State. A large tonnage is also produced, however, throughout all the valleys of the western part of the State, particularly in the Willamette Valley, about Salem. The Hood River Valley is also growing pears in important commercial quantities.

The Yakima district is by far the heaviest pear-producing section of Washington. The Wenatchee district is second in total tonnage, while scattered plantings occur through the other fruit sections.

There is wide variation in the method of handling fruit from these different sections. Some growers depend entirely upon the shipment of fresh fruit to the Eastern States in order to market their crop. In other sections the canneries are depended upon entirely as an outlet for the production. The crop from numerous sections is shipped in part in the fresh state, the remainder usually being canned, while the output of at least one important producing section (Lake County, Calif.) is practically all dried.

HANDLING FRUIT FOR SHIPMENT IN A FRESH STATE.

TIME OF PICKING.

One of the most important questions which face the grower or the shipping organization is that of knowing when to pick the pears. Wide differences of opinion prevail as to the effect upon the keeping quality of the fruit of leaving it on the trees until late or of removing

it from the trees early. In the present practice the size of the fruit is the most important consideration in determining when to pick.

In the investigations here recorded special attention has been paid to the time of picking the fruit. Pickings of pears have been made at intervals beginning before the commercial season started and continued until some time after it was over. Observations of the fruit have been supplemented by chemical studies, the results of which have been presented in a previous report.[3] Tests of the output of carbon dioxid from the fruit following picking at different stages of maturity and under different temperatures of storage have also been made and will be reported in detail in a separate publication. The exact analyses upon which many of the conclusions reached in this report are based have been presented in detail in the paper mentioned.

There is no fixed time at which it may be said that pears are in just the right condition to pick. The time of picking will vary widely with the manner in which the fruit is to be marketed.

If removed from the trees too early, Bartlett pears will tend to shrivel and wilt before ripening. It has been found that the time at which the fruit may be picked without danger of wilting can be determined by testing for the corking over of the lenticels.

As the fruit grows, numerous small light-colored spots can be observed all over its surface. Examination under the microscope reveals the fact that these are minute openings through the skin of the fruit. These lenticels, as they are called, are open during the early growth of the pears. If such a fruit be immersed in a strong solution of methylene blue in water and left for 15 minutes to half an hour, these spots will be colored a deep blue by the stain that has penetrated the tissue. About the time shipping usually commences, however, the lenticels become brown, owing to the formation of a layer of corklike cells over the surface of the opening. After this forms, if the fruit is immersed in the methylene-blue solution, the stain penetrates very little. When the fruit is removed from the stain and rinsed, the methylene blue can be detected only as a faint, thin ring about the outside of the lenticel. The stain will not penetrate the corky layer. Although it has never been tested, it is extremely probable that ordinary laundry bluing, made up in a strong solution, would serve the purpose as well as methylene blue.

After the lenticels are once sealed over, there is little further danger of the fruit shriveling after removal from the tree, and if it has attained sufficient size it can be picked with safety. It has been found, however, that if the fruit is left on the tree for about two weeks longer, a very much superior product will be obtained. The sugar content increases rapidly during this period, and the fruit is

[3] Magness, J. R. Op. cit.

much higher in dessert quality if removed from the tree two to three weeks following the corking over of the lenticels rather than immediately thereafter. The earliest Bartlett pears to arrive on the eastern markets are almost invariably of very poor quality, owing to too early picking.

It has been found, however, that at the temperatures it is possible to maintain in a car during transit, Bartlett pears will arrive on the market in a greener condition if picked early. The fruit trade at the present time demands that pears show mainly green color upon arrival, and with this fact in mind, picking, especially in districts where considerable difficulty is experienced in getting fruit to carry through to market, can not be delayed too long.

It has also been found, however, that late-picked fruit will hold up for a much longer period after it becomes soft and in an edible condition than fruit from the same trees picked early. With the early-picked fruit there is a period of only two or three days during which the pears are in a good edible condition, while fruit from the same trees but picked three to four weeks later will remain in good, firm condition four to five days after becoming soft enough for eating. In districts where little difficulty is experienced in shipping fruit to market, a much larger sized fruit, of higher dessert quality, and one that will hold up longer for the retail trade, can be secured by delaying the initial picking until about 10 days later than is the present practice.

RELATION OF THE CARRYING QUALITY OF BARTLETT PEARS TO THE CLIMATIC CONDITIONS UNDER WHICH THEY ARE GROWN.

During the progress of this work a very careful study has been made of the keeping and carrying quality of fruit from some of these different regions. This study has been supplemented by discussions with some of the leading producers and shippers from each of the various districts. There are wide variations in the climatic conditions under which Bartlett pears are grown in the Pacific Coast States, and these are reflected in equally wide variations in the keeping and carrying quality of the fruit following its removal from the trees.

In Bartlett pears that are apparently in the same state of maturity at the time of picking, there is a marked difference in the number of days required for the fruit from different producing sections to become ripe after removal from the trees. Fruit from some sections requires 12 to 14 days when picked at the height of the season and held at temperatures of 60° to 70° F. following picking before it is in prime condition for eating. Such fruit is usually of a close-grained texture, rather firm when fully ripe, and ripens evenly throughout the whole fruit.

The fruit from some other sections becomes soft ripe much more quickly, even when picked in what is apparently the same stage of maturity and held at the same temperature following picking. This latter type of fruit is usually rather coarse in texture, softer when ripe than the slower ripening pears, and has a marked tendency to become overripe and discolored about the core region while the outside of the fruit appears to be entirely sound. Such fruit from many sections has been found to ripen in so short a time after picking that successful shipments of the fresh pears to eastern markets is impossible. In certain districts canners, unfamiliar with the tendency of the fruit to become overripe at the core before showing external signs of deterioration, have suffered heavy losses by allowing the pears to remain too long before canning.

Canners and pear shippers are fully aware of the wide variation that occurs in the carrying qualities of the pears from different sections, at least in so far as these variations occur in their local territory. It is believed, therefore, that a discussion of the ripening of the fruit as it occurs in the different districts will be of advantage not only to the industry as a whole, but also to all the individual districts. For although fruit from certain districts will ripen more evenly and hold up longer following removal from the tree than that from other sections, there is no place on the Pacific coast where Bartlett pears are grown commercially that they can not be handled successfully, at least for canning or drying, provided proper precautions are taken.

It has been found that Bartlett pears from the Sierra Nevada foothill region east of Sacramento have uniformly excellent carrying and keeping qualities. The same may be said for pears from most of the districts in southern California, particularly the Tehachapi and Antelope Valley plantings. Fruit from the upper Sacramento Valley is very high in carrying quality. In the very large Bartlett pear section, lying along the reclaimed lower Sacramento River, the fruit is also of high carrying quality, although some trouble is encountered with pears from the lower part of this section nearest the coast.

In the Santa Clara Valley the fruit is much poorer in keeping and carrying quality, and fresh shipments from this district have been largely discontinued because of the difficulty in getting the pears through to market in good condition and the excellent cannery market available.

The Bartlett pears grown in the counties bordering on the coast in California are uniformly poor in carrying quality. They become soft ripe quickly after removal from the tree and have a marked tendency to soften and become overripe at the core while still apparently firm on the outside.

In Oregon the Rogue River Valley Bartletts carry the best of any in that State and are comparable to the Sacramento River fruit. Pears from the Salem district ripen quickly and must be handled more promptly after the removal from the tree. In Washington much difficulty has been experienced in handling Bartletts from the Yakima and Wenatchee Valleys for eastern shipment. The fruit ripens rapidly and has a tendency to ripen first at the core. By using the best methods of precooling, shippers have been successful in handling the fruit from the Yakima Valley, though severe losses are still encountered in attempting to ship the Wenatchee grown Bartletts to eastern markets.

From a survey of the fruit as grown under the widely varying climatic conditions of the Pacific coast, it is apparent that a marked relationship exists between the keeping quality of Bartlett pears following their removal from the tree and the summer temperatures under which the fruit is grown. These observations have been made entirely in the pear regions on the Pacific coast, and no attempt has been made to check them by tests in the eastern producing States.

The records of the United States Weather Bureau for various points in each of the main Bartlett pear-producing sections have been obtained, and from these records the average daily maximum and minimum temperatures for June, July, and August have been computed. These records are averages for a large number of years. The temperature records together with notes on the carrying quality of the fruit following removal from the tree are summarized in Table 1.

In certain instances it has been impossible to secure Weather Bureau records of the average daily maximum and minimum temperatures directly in the main pear-producing regions. However, it has been possible to obtain data sufficiently complete to give a very good idea of the general temperature range. As these studies have been carried on, it has become increasingly evident that the summer growing-season temperatures are of great importance in the development of fruit that has a long keeping season.

Bartlett pears grown in the Antelope Valley and other very hot districts in California have a widely known reputation for keeping quality. Often the summer temperatures in this region run to 115° F. The upper Sacramento Valley and foothills of the Sierra Nevada Mountains, also having high temperatures during the growing season, produce pears that can be shipped to any point in the United States. Such fruit is loaded into iced refrigerator cars, shipped without previous precooling, and unless unexpected delays occur usually arrives on the markets in excellent condition.

Pears from the lower Sacramento Valley, in the region between Sacramento and the mouth of the river, are also very good shippers, although occasional trouble is encountered. This is especially true of fruit from the lower and cooler portion of this region. In this

lower valley region fruit is sometimes found breaking down at the core while still sound at the surface, but this tendency is not common in fruit from this section.

TABLE 1.—*Relation between the shipping quality of Bartlett pears from different districts and the temperature conditions under which they are grown.*

District and station.	June.		July.		August.		September.		Remarks.
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	
Antelope Valley, Calif.[1]	.....	.....	.....	.....	.....	.....	.....	.....	Fruit of very highest keeping and shipping quality.
Upper Sacramento Valley:									
Chico	89.3	55.0	98.9	60.2	97.4	58.3	.....	.....	Fruit of excellent keeping and carrying quality.
Red Bluff	87.8	61.6	94.7	66.3	95.1	65.1	.....	.....	
Marysville	87.9	58.0	95.8	60.8	94.6	59.5	.....	.....	
Sierra Nevada foothills:									
Rocklin	86.0	52.7	94.7	58.8	94.2	57.3	.....	.....	Fruit ripens evenly and is of firm texture.
Auburn	85.1	55.0	91.7	61.1	91.8	60.3	.....	.....	
Lower Sacramento Valley:[2]									
Sacramento	82.3	56.2	88.8	58.2	88.8	57.7	.....	.....	Occasionally fruit becomes overripe in transit east, particularly from the lower and cooler portions of this region.
Lake County, Calif.:									
Upper Lake	83.5	50.0	93.2	54.4	92.9	52.6	.....	.....	Fruit holds up well and ripens evenly.
Rogue River Valley, Oreg.:[3]									
Ashland	76.3	47.0	86.2	51.9	85.4	51.5	.....	.....	Considerable difficulty during certain seasons from fruit breaking down in transit.
Yakima, Wash.:									
Moxie	80.9	48.0	88.9	53.1	87.4	51.1	77.3	42.4	Great difficulty in shipping; careful precooling necessary.
Wenatchee, Wash.:									
Wenatchee	74.9	49.0	83.7	55.8	81.0	54.6	71.4	47.6	Tendency to break down at core.
Santa Clara Valley, Calif.:									
San Jose	76.9	48.7	80.9	52.0	79.9	51.3	.....	.....	Fresh eastern shipments practically abandoned because of breaking down in transit.
Santa Clara	77.0	46.5	82.5	50.6	81.5	49.6	.....	.....	
Sonoma County, Calif.:									
Santa Rosa	77.9	45.8	82.0	49.1	82.1	47.1	.....	.....	About the same as Santa Clara Bartletts.
Willamette Valley, Oreg.:									
Salem	72.1	49.7	79.6	53.3	80.1	53.1	.....	.....	Little attempt made to ship to eastern markets. Canneries take total crops.
California coast district:									
Oakland	72.7	52.7	73.0	53.8	70.2	54.3	.....	.....	Fruits very poor keeping; marked tendency to break down inside; Santa Cruz County (Watsonville) Bartlett especially bad.
Watsonville	68.0	47.7	68.1	47.0	68.2	45.5	.....	.....	

[1] The temperature record is not available, but the summer range is the highest of any place listed.
[2] The main pear district is somewhat cooler than Sacramento. Records are not available.
[3] The main pear district is at a much lower elevation and is warmer than the above records show.

The Rogue River Valley district in southern Oregon produces a good-shipping Bartlett pear, though considerable fruit arrives on the markets in an overripe condition. This fruit approximates that from the lower Sacramento Valley in carrying quality, but somewhat more trouble is experienced with it, owing to a longer haul to market. Most of this fruit goes east via Sacramento. The temperatures given for this district are for Ashland, a markedly cooler location than the main pear plantings centering about Medford.

In the Yakima and Wenatchee districts of Washington very great difficulty has been experienced in shipping fruit through to eastern markets. In former years the losses from fruit breaking down in transit were very heavy. By prompt and very efficient precooling, however, it has been possible to handle the Yakima Valley fruit during recent years without much loss. The Wenatchee Valley, with a somewhat cooler growing season and less cold-storage capacity for precooling, still suffers considerable loss of Bartlett pears on eastern shipments.

The temperature range in these districts (the Yakima and Wenatchee Valleys) is not markedly lower than that at Sacramento. It is true, however, that during a normal season the peak of the picking season in the former regions is not reached until the first week in September. It will be noted that September temperatures represent a sharp drop below those of July and August. This may account in part for a greater difficulty with this fruit than the records would seem to warrant.

In the Santa Clara Valley of California, centering about San Jose, in the Sonoma County section north of San Francisco, and in the Willamette Valley of Oregon attempts to ship Bartlett pears to eastern markets have not generally met with success, except in the case of very early picked fruit. These districts, near enough to the coast to have a comparatively cool climate, produce Bartletts excellent for cannery purposes, but with a carrying season too short to allow them to be readily handled for eastern shipment. The tendency to break down internally is marked. It is probably true, however, that some of this fruit, even of later pickings, could be shipped successfully were it possible to precool it efficiently.

In the counties near the coast, and especially in districts directly adjacent to the coast, a few Bartlett pears are produced. Grown in this extremely cool climate, the pears are of the poorest keeping quality of any under observation. Such fruit is particularly likely to break down internally, and it must be handled very carefully, even for use by canneries, if it is to be utilized without loss.

It is not the intention in this report to imply that the temperature of the growing season is the only factor involved in determining the rapidity of the breakdown in pears following removal from the tree. In the territory studied the humidity varies inversely with the temperature, the regions of high temperature being low in humidity, and vice versa. This may be equally important with temperature in its effect on the fruit. Soil and soil moisture undoubtedly are factors entering into the keeping quality of the fruit to a marked extent, but the relationship to temperature during the growing season seems to stand out when the conditions characterizing the different districts are considered.

Observations indicate that this same relationship of temperature and humidity during the growing season to keeping quality holds in regard to many other deciduous fruits, though not necessarily in the same degree as with Bartlett pears. Plums, prunes, cherries, apricots, and other fruits seem to show a similar tendency toward poor keeping quality when grown under particularly cool conditions, but they have not been studied in sufficient detail to warrant a definite statement.

MARKETING BARTLETT PEARS FROM DIFFERENT DISTRICTS.

The trade, through long experience in handling fruit from different sections of the country, has become thoroughly acquainted with the characteristics of pears from different regions. Consequently, the fruit is now utilized largely in the manner to which it is best adapted.

Fruit dealers in the districts in which the pears produced are of the highest carrying quality usually ship the bulk of their crop to eastern markets. In some regions the early-picked fruit is shipped, but the later picks, which are of poorer carrying quality, are marketed through the canneries. In the coolest regions no attempt is made to ship Bartletts any great distance. They are sold to canneries or marketed locally.

PRECOOLING PEARS FOR SHIPMENT.

The advisability of precooling Bartlett pears before shipping is one that varies greatly with the particular district under consideration and with the facilities that are available for cooling the fruit. By precooling is meant placing the fruit in a cold-storage room and cooling it thoroughly before loading it into a car or holding a car of fruit on a siding adjacent to a plant equipped to circulate cold air through the car, thus cooling the fruit more quickly than is possible by simply placing ice in the car.

In those districts in which little difficulty is experienced in getting fruit through to market there is no reason for departure from the present practice. The fruit should be packed as promptly as possible after removal from the tree, loaded into iced refrigerator cars, and started to market at once. At the present time the railroad tariffs allow the addition of salt to the ice in the cars, which greatly hastens cooling. Tests carried on by the Office of Preservation of Fruits and Vegetables in Transit and Storage of the Bureau of Markets and Crop Estimates, United States Department of Agriculture, have shown that 200 pounds of salt added to the ice in each bunker at the time of loading is of very great value in quickly cooling the fruit to the minimum temperature that it is possible to maintain in the car.

In shipping fruit from districts in which pears have poor carrying qualities, precooling has proved of great value in putting the fruit on the market in good condition. The success or failure of precooling will depend, however, primarily upon the answer to one question,

namely, how soon after the removal of the fruit from the tree can the pears themselves be cooled to 30° F. or below? If the fruit after picking can be reduced to this temperature in 24 to 36 hours, there is no doubt that such treatment will be of great advantage in the shipping of the fruit.

Such results can be attained, however, only by having a very large refrigeration capacity in proportion to the quantity of fruit handled. Marked success has been attained by precooling in the Yakima Valley in Washington, and an outline of the methods followed there will indicate the procedure that has given greatest success in handling Bartlett pears.

The rooms in which the pears are to be placed are cooled to below 28° F., in many cases the temperature being reduced to 10° to 20° F. before the fruit is brought in. The fruit is taken to the storage house in lug boxes immediately after picking. As it cools, the room temperature rises, but the air in the rooms is kept down to 28° F. or is again reduced to that temperature as quickly as possible after the fruit is placed in the room. After 36 to 48 hours at 28° F. the fruit is removed to a warmer room, held at about 40°, where it is graded, packed, and quickly returned to the 28° room. In most cases the fruit is not in the packing room for more than 30 minutes to an hour, and it is probable that the temperature of the fruit itself does not rise more than 1 or 2 degrees during this time. The fruit is shipped at any time after packing, from immediately thereafter up to a month later. The bulk of the crop, of course, is forwarded at once.

Pears cool very slowly when taken into cold storage, and at least 24 hours will be required to reduce the unwrapped fruit in boxes to the desired temperature. If the fruit is wrapped before cooling or if the boxes are closely stacked in the rooms, a much longer time is required, due to the insulating effect of the paper and the reduced aeration in the boxes. In this connection the need for an armored thermometer that can be inserted in the fruit itself, by means of which its temperature can be determined, should be emphasized. Low temperatures retard the ripening processes in the pears only after the fruit itself reaches that lower temperature. This is very often a considerable time after the air is at the desired temperature; this is doubly true if the fruit is wrapped.

Very careful tests have been made of the rate of ripening of Bartlett pears at different temperatures by measuring the carbon dioxid given off by them. It has been found that they ripen about twice as rapidly at 37° F. as at 30° F. It is not possible to stop entirely the ripening of the fruit at any temperature above the freezing point, which in Bartlett pears has been found to be between 27° F. and 28° F. However, at temperatures under 30° F. the fruit ripens so slowly that a number of days at this temperature makes only a slight difference in the time the pears will hold up after removal from cold storage.

In the districts where difficulty is experienced in keeping fruit shipped to eastern markets in good condition, precooling, when carried on as outlined above, has proved to be of great advantage. In some instances, however, commercial precooling has failed to give satisfactory results. The cause of this has invariably been the failure to cool the fruit in a limited time. Overtaxing the refrigeration capacity of the plant or attempting to cool closely stacked boxes of wrapped and packed fruit has in many cases resulted in a rate of cooling so slow that the injury caused by delay incident to the cooling has been greater than the benefits gained. Since ripening goes on until the fruit is actually reduced to the minimum temperature, a delay incident to cooling is as serious as a delay while the fruit is en route. If shipment is delayed without actually getting the fruit cooled through and through, the results will be less satisfactory than if the pears are shipped immediately after picking.

HANDLING FRUIT FOR THE CANNERIES.

The handling of Bartlett pears for the cannery is quite different in the ultimate object to be attained from the handling of the same commodity for shipment in a fresh state. With the cannery man a fruit of high dessert quality is the first consideration. The number of days that must elapse between the time of picking and the time the fruit is in prime condition for canning is of less importance than the number of days during which the fruit may be canned or, in other words, between the time when the fruit becomes soft ripe and the time when it begins to break down. There is no doubt that the consumption of canned pears would be greatly increased if all this fruit that goes on the market was of the high quality found in certain cans. There is also no doubt that the greatest factor in the production of canned fruit of low eating quality is the inferiority of the fruit itself before canning. With proper handling there will be no occasion for much of the low-grade product that now goes into cans in many plants.

Perhaps the greatest single cause of poor quality in canned Bartlett pears is picking the fruit too early. There is a marked increase in sugar in fruit taken from the tree at successive intervals during the commercial picking season. During a delay of two weeks in picking the sugar content of the fruit will often increase by 10 per cent. In addition to the increase in sugar, late-picked pears lose much of the astringency characteristic of fruit picked early in the season. The highest quality in Bartlett pears is not attained until the fruit is showing a distinct tinge of yellow color beneath the green at the time of its removal from the tree. Such fruit, if held at temperatures of 60° to 70° F., will be in good condition for canning comparatively soon after removing it from the tree. The exact time will vary with the section in which the fruit is grown. After

ripening, however, this same fruit will remain firm and without decay for several days, giving a long period in which to put the fruit into the cans.

It is obvious, however, that if the pears are left on the trees until late in the season the cannery will have a large quantity of fruit to handle within a comparatively short time. In many cases this can be remedied only by putting the fruit, or a portion of it, into cold storage and holding it there until such time as it can be utilized to advantage.

THE COLD STORAGE OF BARTLETT PEARS.

The cold storage of Bartlett pears has passed the experimental stage, and it only remains for handlers to adopt the best methods in order to obtain a high-grade stored product. This variety of pear has been held in commercial storage for a period of three months, and in experimental storage up to five months, practically without loss.

The two factors which in the past have been responsible for the greatest loss to pear-storage men are (1) allowing the fruit to become too nearly ripe after removal from the tree before putting it in storage and (2) holding the storage rooms at too high a temperature. To these should be added a third factor, namely, pear storage scald. These factors will be discussed individually.

If fruit is to be held in cold storage it is essential that it be placed in the storage rooms as soon as possible after removal from the tree. It is impossible to stop entirely the ripening processes going on in fruit by cold storage, though the rate of ripening can be so reduced that several months will be required to attain the same degree of ripeness that would be reached in 10 days to two weeks at ordinary temperatures. In storing for a cannery the fruit should be placed in storage immediately after removal from the tree for the best results. This is especially the case if fruit from districts producing pears of very poor keeping quality is being stored. This fruit, if left on the tree until in the best condition for canning, will ripen within three or four days after removal from the tree. Such fruit should be in storage within 24 hours at the maximum from the time of picking and preferably on the same day it is picked. This is possible only if the storage house is within trucking distance of the orchard.

STORAGE TEMPERATURE.

Commercial experience, as well as detailed tests by the Bureau of Plant Industry, have shown that for the best results in cold storing Bartlett pears the temperature should be 30° F. or slightly below. This is the temperature that has been found best in the Yakima Valley district in Washington, where fruit handlers have had the widest experience in the commercial cold storage of Bartletts of any section in the Pacific Coast States. As mentioned earlier in this report, it

has been found that Bartlett pears respire about one-half as fast at 30° F. as they do at 37°. The average respiration rate at 60° F. is about 10 times that at 30°. It has also been found that fruit can be held fully 10 times as long in storage at 30° as at 60° F.

Fruit when held in cold storage until full yellow and soft is invariably of poor dessert quality. It is flat in taste and lacking in flavor. Apparently such fruit has not developed many of the compounds that give it the peculiar odor and flavor found in fruit that has not been held in storage at low temperatures. In the case of Bartlett pears, however, it has been found that fruit may be held in storage for periods up to two to three months and then taken out while still hard and green, provided it has been held in temperatures of 28° to 30° F. Such fruit should be ripened at a temperature of 60° to 70° F., and when removed from storage it will develop much of the aroma and flavor found in pears that have ripened in normal temperatures. Invariably it has been found that pears handled in this way, by storing at the minimum temperature until the fruit is to be used and then removing from storage entirely and ripening it at temperatures of 60° to 70° F., have given a product of higher dessert quality than that obtained by any other storage method. This method of handling is to be recommended, regardless of whether the fruit is intended for canning or for a late fresh-fruit market following removal from storage.

There has been some criticism among cannery men of holding pears at so low a temperature. It has even been said that such a procedure will cause the pears to discolor in the can. In order to determine whether or not a season at low temperature injures the fruit for canning, a quantity of pears from two different orchards was removed from storage on December 29, 1920, and was canned on January 4, 1921, almost five months after picking. This fruit made a canned product of very good quality and of splendid appearance, though there was considerable waste in preparing the pears for canning after so long a season in storage. This practice is not to be recommended, nor is it desirable from the canners' viewpoint that pears for the cannery be held more than two months in storage. The fact, however, that this fruit after so long a storage season still made an excellent canned product entirely refutes the theory that cold-storage pears, particularly if held at low temperatures during storage, make a poor quality of canned fruit.

Another important matter to the canner is the fact that pears from the districts producing fruit of poor keeping quality, such as those along the California coast, can be handled safely through cold storage. During the summer of 1920 a large quantity of pears from Santa Cruz County, Calif., supposed to be among the poorest keeping Bartletts in the State, was put in storage under the observation of the writer. This fruit was held at 30° to 31° F. for more than a

month. Upon removal from cold storage the fruit ripened normally and made a canned product of as high a quality as though it had not been placed in storage.

PEAR SCALD.

During recent years, as Bartlett pears have been held in cold storage in constantly increasing quantities, fruit has frequently come out of storage in a blackened condition. The skin is black or brown and tends to slough off very readily. The injury usually does not penetrate the tissues very deeply, but when much of the surface of the fruit is affected it renders the pear practically worthless.

Many of the men who have put fruit in cold storage have attributed this trouble to freezing in the storage rooms. This is not the case, however, for fruit that has been held at temperatures never below 35° F. has been found badly scalded upon removal from storage. It is apparently a trouble of pears in cold storage closely analogous to the storage scald of apples.

During two years of investigational work on pear storage the writer found that this trouble developed several times when fruit was removed from storage. In pears from the same trees and held under exactly similar conditions in the storage rooms, it has invariably been the early-picked fruit that scalded upon removal from storage. During the summer of 1920, Bartletts were picked from the same trees in a typical orchard in Sacramento, Calif., on June 30, July 9, 14, 24, August 3 and 13. Part of each lot of this fruit was held at 35° and part of it at 30° F. On September 24 the fruit was removed from the room having a temperature of 35° F. and held at ordinary room temperature. At that time it was yellow ripe, though still firm. The first three lots picked, from June 30 to July 13, showed practically 100 per cent scald. Lot No. 4, picked July 23, showed approximately 50 per cent scald, while lot No. 5, picked 10 days later, was almost entirely free from it. No scald showed in lot No. 6, picked on August 13. Fruit from Santa Clara, Calif., showed practically the same condition. Apparently, early-picked fruit is far more susceptible to scald than that picked late. It is particularly necessary, therefore, that fruit be well matured on the tree before picking if it is intended for cold storage.

In all of the tests so far conducted there has been less scald in fruit held at 28° to 30° F. than in that held at higher temperatures. It seems probable that this is because the fruit has been removed from storage at the lower temperature when in a hard, green condition. Scald appears to develop mainly on fruit that is removed from cold storage in a yellow-ripe condition. The late picking of fruit intended for cold storage, followed by its prompt removal to the cold-storage rooms, appears to be the best insurance against scald. Such fruit can be removed after a reasonable season in cold storage while

still firm and green tinted. Not only will this treatment give the greatest security from scald, but it will also give the highest quality product when it becomes soft ripe.

SUMMARY.

For two years chemical and physiological studies of the ripening and storage of Bartlett pears have been carried on.

The time of picking and method of handling pears vary widely in accordance with the manner in which the fruit is to be consumed.

For fresh shipment the fruit will not shrivel if picked after the lenticels are thoroughly corked over. A much superior product will be secured, however, if the initial picking is delayed until at least two weeks later than this time.

Early-picked pears after removal from the tree will remain in a hard, green condition for a much longer period than late-picked fruit from the same tree if held under normal temperature or iced-car temperature conditions.

Early-picked pears, however, after they once become soft and ripe break down and decay very quickly. Late-picked pears after softening remain in prime condition for eating for a much longer period.

There is a wide variation in the length of time the fruit from different districts will hold up following its removal from the tree. In general, the districts with relatively high temperatures and low humidity during the growing season produce Bartlett pears with the best carrying and keeping qualities.

Precooling pears before shipment is to be recommended in districts where the fruit has poor carrying qualities, provided the refrigeration capacity is sufficient to cool the fruit to 30° F. within 24 to 48 hours following its removal from the tree.

If the highest quality is to be secured pears for canning should not be removed from the tree until they show a pronounced yellow ground color beneath the green.

Bartlett pears can be held successfully in cold storage for two to three months and, if necessary, even five months, if proper methods are employed.

If fruit is to be held in cold storage, it should be allowed to come to the stage recommended for cannery picking before removing it from the tree. Early-picked fruit has a marked tendency to scald in cold storage.

Fruit should be removed to the cold-storage rooms immediately after picking and cooled quickly.

Fruit should be held at 28° to 30° F. until desired for use; then removed and allowed to ripen at 60° to 70°. This will give the highest quality for storage pears.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922